agitation—and that there are ample grounds for putting him on his trial. Let us however suppose the impossible case of his absolute acquittal, I maintain that this negative result would be worth all the labour of obtaining it—eliminating, as it would do, one, and that the most conspicuous of probable causes, and so narrowing our inquiries to those that remain. The more likely event, however, will be that whilst the sun will be proved to be the chief promoter of these disturbances, his accomplices, and their various degrees of participation, will be dragged more prominently before the light.

Nor do I desire that the "innate power" I have attributed to the sun, and denied to other elements, should be misunderstood. I have used the term as the only one available to mark strongly the relative influences at work. I by no means intend to use the word "*innate*" in an absolute sense, or even to imply that the forces of the sun are self-generated and self-maintained. The object of this paper is a strictly practical one, and is not to be taken as intended to contribute one word to speculations on the constitution of the sun. But though disclaiming speculation, I may, on behalf of my practical object, point out that we already possess what may at least be claimed to be presumptive evidence that the sun is not exempt from external influences. I allude to the remarkable apparent connection which the researches of De la Rue, Stewart, and Loewy have established between the behaviour of the sun-spots and the positions of some of the planets, particularly Venus, the Earth, and Jupiter. I say that the mention of a result so well calculated to excite speculation, aids my practical object. I mean that by following up the hint given us by these most remarkable researches, we may be led to a more complete knowledge and more philosophical conception of the structure of the universe.

And I would here remark that I have urged the study of the sun from the meteorological point of view in order to give a practical justification for the adoption of definite practical steps. But that study is recommended by even higher considerations still, by the insight it must give us into cosmical relations, and the help it will afford us in seeking to understand something, if not of first causes, at least of causes of the highest order that our limited intelligence can grasp and reason on.

The more one reflects on the neglect of the sun justly chargeable against us, the more one wonders at it. It is like the case of a man placed before a steam-engine for the first time, and seeking to learn its principle and action by counting and measuring the bolts, screws, and rods, without giving a moment's attention to the source of power—the furnace and boiler. What they are to the steam-engine the sun is to us, and it is astounding that men should dare to undertake a solution of the complex and mysterious fabric which surrounds us without giving a foremost place in their investigations to the source of all material life and power.

Civilisation has been variously described and defined. It seems to me to imply above all things *completeness*. It aims at supplying all wants, at removing all obstacles to thought and to action, at making good all deficiencies, at remedying all evils moral and material, at guarding against all dangers, at promoting all beneficence, at extending and perfecting all knowledge. Science, as the most potent guide and instrument of civilisation, needs also to be complete. A harp with broken strings can discourse no music,—a chain with unconnected links can sustain no weight. Science, as our President so eloquently impressed upon us in the address with which he opened this Section, is one and indivisible. It has been broken up by man into its various recognised branches to serve his convenience and to assist the weakness of his intelligence; but nothing, as the same authority told us, is more subversive of truth and more hindering to progress than to regard these subdivisions as representing the actual order of nature. There must be doors of communication between the observatory, the laboratory, and the mathematician's study. The isolation of particular fields of research is no longer tolerable: each passes, however indirectly and insensibly, into the other through that "border land" which, as our President reminded us, "recent investigation has shown to be so fertile of discovery."

The study of the sun stands on this "border land." It belongs but very partially to the domain of the ancient astronomy, it possesses some holding in the provinces of chemistry and geology, and more still in that of physics, it claims as its right (as what branch of science does not?) the devotion of the mathematician, and it rules almost supreme in meteorology.

This study asks to be recognised and provided for. How much longer will the demand be disregarded?

*IN WHAT WAY AND AT WHAT STAGE CAN TECHNICAL INSTRUCTION BE BEST INTRODUCED INTO OUR SYSTEM OF NATIONAL EDUCATION**

IT will simplify the consideration of the subject, the discussion of which I have been requested to introduce, if we admit frankly that in England at any rate (I am glad to believe that Scotland is more fortunate) we do not possess a system of national education. Such a system, as I conceive it, should afford to all the children of the nation adequate elementary instruction, and, moreover, should offer to all, so far as their capacities and other circumstances will enable them to take advantage of it, full opportunity for further mental cultivation. There are lying before me the calendars of two German schools for boys of the middle class intended for a mercantile or industrial career: the Friedrich-Werder Gewerbe, or Trade School of Berlin, and the Real Schule, under the direction of Dr. Schellen at Cologne. The courses of each of these institutions following after some preparatory teaching in an elementary school or at home, where reading and writing together with a little arithmetic have been acquired, retain their pupils during nine or ten years; and boys who, according to the reports, were to become mechanical engineers, builders, postmasters, merchants, and chemists, left those schools last July, having attained the ages of seventeen to twenty years. The Real Schule of Cologne, the average number of whose pupils is 580, has 28 masters; the Gewerbe Schule of Berlin, averaging 540, has a staff of 32 masters. In every German town of the least importance there are, in addition to the Gymnasium or Classical School, one or more technical schools resembling those of Berlin and Cologne; the numerous Universities and Polytechnic Institutions furnish the requisite staff of teachers. The fees are small. I have no information as to those of the schools which I have quoted, but I find from the prospectus of another very celebrated trade school, that of Barmen in Westphalia, that its school fees for the year are from 3*l.* in the lowest to 6*l.* in the highest class, and that boys whose friends do not reside in the town are boarded for 25*l.* The governments, the municipalities, and private persons vie with each other in placing at the disposal of poor scholars of the elementary schools who have shown superior capacity, the means of continuing their studies in these secondary schools.

I need not describe the elementary schools of Germany and Switzerland; it is now well known that, in them, the children of the poor receive, up to the age of fourteen years, sound elementary instruction, not confined to reading, writing, and arithmetic, but including geography, the outlines of the history of their own and other European countries, a modern language, some elementary teaching in science, and instruction in the religion which their parents acknowledge.

As contrasted with a system of education such as I have referred to and excluding the great public schools, available only to the rich, we have in England for the middle classes schools like those attached to King's and University Colleges, the City of London School, the Bristol Trades School, and, thanks to the Endowed Schools Commissioners, a few efficient or at any rate progressive grammar and endowed schools, amongst which I would more particularly name the school at Giggleswick, near Skipton, as one where instruction in science has been included in the general plan of instruction; and a small number of exceptional private schools in which a praiseworthy attempt is made to adapt the instruction to the requirements of industrial and commercial classes. These schools however rarely retain their pupils beyond the age of fifteen to seventeen years, and when all are reckoned they are utterly inadequate to the wants of the population.

Of elementary school buildings we shall soon have a sufficient number, and it is probable that the duty of the parent to send his child to school will, in some way or other, be in all cases made a legal obligation; but so long as the necessity of rendering our training schools for elementary teachers thoroughly national and efficient is not acknowledged, and so long as the instruction of the children in elementary schools is left in a great measure to the care of other ill-taught children, called pupil-teachers, of from thirteen to seventeen years of age, we cannot hope that our poor will receive proper elementary instruction.

Until the English approach the German schools in number and value it would be vain to expect that technical instruction will be universally accessible, and we can only hope for its gradual introduction, availing ourselves of existing resources, with such improvements as may be looked for under the stimulus of the increasing interest evinced by some of our great corporations, by the parents themselves, and consequently by the Legislature.

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* A paper read before the Social Science Association, Oct. 1, by Mr. B. Samuelson, M.P.

One important step in the right direction has lately been taken:—Although the political chief is still a species of odd man whose duties include the passing of Ballot Acts, the suppression of foot-and-mouth disease, and the negotiation of Washington Treaties, the Government departments of literary instruction and of Science and Art have been placed under the control of a single permanent administrative head.

I understand technical instruction to include, besides the teaching of industrial manipulation, which for our present purpose we may exclude, firstly, drawing, mathematics, and the physical sciences, which are the bases of the industrial arts; and secondly, the application of those sciences and of the art of design to industrial purposes. I should place in the first division such subjects as:—

Pure Mathematics.
Geometry.
Theoretical Mechanics.
Chemistry.
Physics.
Geology.
Physical Geography.
Biology.
Astronomy, &c.;

and in the second—

Building Construction.
Naval Architecture.
Applied Mechanics.
Machine Construction.
Chemical and Manufacturing Technology.
Metallurgy.
Agriculture, &c.

Although this list is incomplete, it will be obvious that the field is too wide to be covered within the school period, even when the pupils remain at school to the age of adolescence; bearing in mind always that instruction in technical subjects to the exclusion of other branches of a liberal education would defeat its own object. Much more is this the case with children leaving school between the ages of thirteen and sixteen. The choice of subjects must vary with the age at which school instruction is to terminate, and with the future career of the scholar.

A condition precedent, however, to the possibility of technical instruction is a due provision of science teachers. For these we must look, in the main, as to elementary schools, to our training colleges, assisted by such institutions as the Science School of South Kensington, and as to secondary schools, to the Universities, and to institutions like King's College, University College, and Owens College. The training colleges should add a third year to their curriculum; instruction in mathematics and in some of the other subjects which I have included in the first division should be part of the obligatory course; and no elementary school containing, for example, 100 children and upwards should, after a certain date, receive the Parliamentary grant on results, unless it had a teacher who had passed satisfactorily in Geometry, in Physical Geography, and in Physics or in Biology. A man thus qualified, having become familiar with the method of science, could, if he chose, afterwards acquire other theoretical subjects as well as those of application, included in the second division; for instance, machine construction, chemical technology, or agriculture—availing himself for that purpose, as to the first class of subjects, of the annual courses for elementary teachers at South Kensington, or of any other means of instruction which may be within his reach. But if he stopped short at the limited but exact instruction in theoretical science which I suppose him to have obtained in the training college, he would be infinitely better qualified as a teacher than if during that course he had taken up a greater range of subjects superficially. Whether he be competent to teach many subjects or not, the children of the elementary schools whom he is to instruct have not time to acquire more than the rudiments of one or two theoretical sciences. At the same time an elementary teacher, who is qualified to give instruction in the applied sciences, will find employment in adult classes, such as those in connection with the Science and Art Department.

Assuming, then, that every elementary school for 100 pupils and upwards, which would include the principal village schools, had a master or assistant qualified in science, the course of such a school should include, for all the children, linear drawing and lessons on common objects which would be illustrated by locally accessible specimens; the ordinary reading-book should also describe in familiar language the phenomena of nature. Those who are acquainted with the admirable text-books on Elementary Science of Prof. Balfour Stewart, Dr. Roscoe, and others, cannot doubt that the task of compiling such a reading-book will be undertaken by competent hands, as soon as the want of it becomes felt. Indeed, I am not sure that it does not already exist amongst the publications of the Irish National Board. The older children, those between the ages of ten and thirteen, should receive instruction in Physical Geography, in the elements of Trigonometry, and, from the age of eleven or twelve, in the rudiments of Biology or of Physics, perhaps, in some exceptional cases, of both. More cannot be done for them in the elementary school; a few should be drafted into the secondary school; but the greater number would at the age of thirteen become full time-workers in the field, at the bench, or in the factory; possessing, however, as is now but rarely the case, the elementary instruction required for taking advantage in their leisure hours of the science classes which are to be found in almost every district of the United Kingdom. How much may be done there is evident from the success of the Andersonian University in your city, with its 1,400 students, to whose founder belongs the honour of having been, more than a century ago, the originator of scientific instruction to the working classes. Children thus taught from the commencement by such masters, when they afterwards receive instruction in science, would not be subjected to, and would revolt against, cram like that recorded in the Report of the Science and Art Department for the present year, in which Prof. Ramsay, the examiner in Geology, says that "candidates answer one of last year's questions in place of one of this year's, as if they had been specially crammed in last year's examination;" and Prof. Carey Foster, acting with Dr. Tyndall as examiner in Acoustics, Light, and Heat, states that a good number of candidates in the advanced stage "suppose that in order to *damp* the vibrations of a string it is needful to *wet* the string," and "that a ship is the kind of vessel that would usually be employed for containing air."

Amongst other conspicuous examples of adult instruction in science given to the class whose education has been received in elementary schools I may name the lectures for working men of Owens College, numbering more than 600 students, under the gratuitous tuition of the professors of that institution, and those of the Miners' Association of Cornwall and Devon, organised some dozen years ago by Mr. Robert Hunt, F.R.S., Keeper of Mining Records, whose teachers seek out the working miner in his village and make him familiar with the laws of the forces and the properties of the matter with which he is brought into contact in his daily work. But time is wanting to allude further to the subject of adult elementary instruction in science, nor will I enter into the question of science teaching in our great public schools, which has been inquired into by Mr. Norman Lockyer, F.R.S., the secretary of the Royal Commission on Scientific Instruction, whose report will doubtless be forthcoming before long.

In secondary schools, assuming the existence of competent teachers, and that they retain their scholars from the age of eight or nine to sixteen or seventeen—I should commence, as in the elementary school, with lessons in drawing and on familiar objects, and in Physical Geography; and introduce Mathematics, beginning with Geometry at the age of eleven or twelve, continuing it until the pupil leaves school; systematic instruction in the elements of natural science might begin at the age of ten to eleven with Natural History, including Geology; and the six years until the pupil leaves at the age of sixteen or seventeen could be made readily to include successively the elements of that science and of Physics and Chemistry. With the exception perhaps of applied mechanics, it would not in my opinion be possible to include the applied sciences, but the teacher would illustrate his instruction by practical applications. Work in the laboratory is a necessity if a thorough appreciation in kind, however limited in extent, of natural science is to be acquired; but the experience of the Rev. W. Tuckwell, of the College School at Taunton, communicated to the British Association, and of others, shows that a school laboratory need not cost more than 200*l*. to 400*l*.

Only in those cases where school education is continued to the age of eighteen or nineteen years would it be desirable to introduce such subjects as building, or machine construction, or chemical technology. In all other cases more real progress would be made by devoting all the available time to theoretical science. The scholar who enters into active life as an apprentice at the age of sixteen or seventeen, would see in the workshop the application of the principles which he would have learnt at school, and, if diligent, he would find opportunities of further study in adult classes, in factories, and in text-books on special subjects. For instruction in the entire range of theoretical and applied science it would be necessary that the student should continue the course, commenced during the school age, at the University or at a Polytechnic Institution such as there is now some hope that the Science School at South Kensington may become.

Although I have excluded instruction in technical manipulation from the subject of this paper, I think it right to add that the students of King's College and of King's College School save much time and drudgery during their pupilage by the practical skill acquired in the workshops attached to the College, and that according to competent observers like Mr. Nussey, of Leeds, the artisans of Elberfeldt, Crefeld, and other continental towns derive great advantage from the schools of design and so-called weaving schools.

I should not fulfil my duty if I were to conclude this paper without acknowledging, though no alarmist in regard to foreign competition, that other nations, less energetic, less rich in accumulated capital and practical experience, and without the advantage of our great mineral resources, are, thanks in a great measure to their superior technical training, making relatively greater advances than ourselves in many branches of industry, and that the conviction of the necessity for such training has not arisen amongst ourselves a day too soon. Happily it has arisen, and in the most desirable quarters. Manchester, by the judicious enlargement of Owens College, to which its merchants and manufacturers have quite recently contributed a sum approaching 200,000*l*.; Yorkshire, by the establishment of the College of Science at Leeds, to which secondary schools of science are to be affiliated; the Company of Clothworkers, by the foundation of scholarships, and the endowment of a chair of textile technology in the Yorkshire College; the University of Durham, and the coal-owners and manufacturers of the North of England, by their joint foundation of the School of Science at Newcastle; Oxford, by its patronage of the College to be established at Bristol; and the Company of Merchant Adventurers, by the aid which it is giving to the Trade School of the same city—are not only directly promoting the higher technical instruction amongst the populations in which their work is done, but will furnish competent teachers to the elementary and secondary schools of their own and other localities. I think there is no fear that a work of such national importance once so actively begun will suffer any relapse; but it will be in the power of this Association to promote by discussion and advice its intelligent and economical organisation.

SOCIETIES AND ACADEMIES

PARIS

Academy of Sciences, Oct. 5.—M. Bertrand in the chair.—The following papers were read:—Researches on the conditions of resistance in cylindrical boilers, by M. H. Resal.—On the exact values of the angles in the crystals of titaniferous iron, by M. N. de Kokscharow.—Report on the machine for freezing by the evaporation of methylic ether, invented by M. Ch. Tellier; and on the preservation of meat in the air, cooled by this apparatus, by the Commissioners, MM. Milne-Edwards, Peligot, and Bouley.—On the temperature of the sun, by M. J. Violle. The author starts with the fundamental equation $\alpha^\theta - \alpha^t = \frac{\omega}{s}\alpha^x$, and from determinations of the intensity of solar radiation assigns the value 1550° to what he calls the *effective temperature* of the sun. The true mean temperature of the surface of the sun is estimated at 2,000°.—Note on magnetism, by M. J. M. Gangain, a continuation of former researches.—Seventh note on the conductivity of ligneous bodies, and of other substances which are bad conductors, by M. Th. du Moncel.—Experimental researches on explosive substances, by MM. Roux and Sarran.—On a register giving continuous indications for the determination of the law of variation of pressures produced by the gases of gunpowder, by M. Ricq.—On the synthesis of purpurine, and of some analogous colouring matters, by M. A. Rosenstiehl.—New observations on the chemical composition of the waters of Bagnères-de-Luchon, by M. E. Filhol.—Method of determination of copper by means of titrated liquids, by M. Pr. Lagrange.—Comparative and critical examination of the hypotheses which have been advanced to explain the figure of comets and the acceleration of their motion, by M. H. Champion. The author attempts to show in this memoir: (1) that a force directed along the radius vector develops in the two opposite parts of an elliptical orbit separated by the major axis, two tangential components of contrary signs, of which the effects are exactly compensating; (2), that the force gives rise to a third component opposed to gravitation, of which the final result is to increase the dimensions of the orbit; (3), it is shown that at the distance at which comets' tails commence to be seen, the rays of the sun would not produce an appreciable elevation of temperature in a highly rarefied substance.—On the comparative chemical composition of the different parts of the vine when healthy and when attacked by *Phylloxera*, by M. Boutin.—Experiments made at Cognac on phylloxerised vines with the coal-tar recommended by M. Petit, by M. P. Mouillefert.—Experiments made at Montpelier with the same substance, by M. Alph. Rommier.—Observations on the points gained by science concerning the known species of the genus *Phylloxera*; a letter from M. Signoret to the perpetual secretary.—Observations concerning the recent communication of M. Balbiani on the different known species of the genus *Phylloxera*, by M. Lichtenstein.—Trial of infection of a healthy vine by putting *Phylloxera* in contact with its roots, by M. Delorme.—On the means proposed to check the propagation of *Phylloxera*, the method of uprooting in particular, by M. P. Naudin.—Experiments on a method of treatment of phylloxerised vines, by the sap of a Euphorbia, by M. L. Balme.—On the appearance of *Phylloxera* in the canton of Geneva, and on different curative measures proposed, by M. E. Ador.—The Minister of Foreign Affairs transmitted further details of the recent eruption of Etna.—M. Dumas announced that the news received from the first four Transit of Venus expeditions was satisfactory on all points.—On the pretended Saharan Sea, by M. A. Pomel.—Observations on the ancient central sea of the Tuniso-Algerian Sahara, by M. Virlet d'Aoust.—On the theory of curves in space of *n* dimensions, by M. C. Jordan.—Electro-diapason of variable period, by M. E. Mercadier.—Electro-spectral tube, or "fulgurator," for the observation of the spectra of metallic solutions, by MM. B. Delachanal and A. Mermet.—Note on supersaturation, by M. Lecoq de Boisbaudran.—On the action of bromine on certain alcohols, by M. E. Hardy.—Note on the production of oxamic acid by the oxidation of glycocol, by M. R. Engel.—Action of heat on diphenylmethane and phenyl-toluene; on the products of the reduction of benzophenone, by M. Ph. Barbier.—Curious association of garnet, idiocrase and datholite, by M. J. Lawrence Smith.—Balloon meteorological observations, by M. G. Tissandier.—Note on the spectroscopic observations made during the balloon ascent of Sept. 24, for studying variations in the extension of the colours of the spectrum, by M. W. de Fonvielle.—On the feeble influence which diluvian waters have exercised on the formation of the valleys of the Paris basin, by M. E. Robert.

BOOKS RECEIVED

BRITISH.—Synopsis of an Arrangement of Invertebrate Animals in the Free Museum of Liverpool, with Introduction by Rev. H. R. Higgins (Marples).—Babington's Manual of British Botany. 7th edit. (Van Voorst).—Mineralogy: Frank Rutley, F.G.S. (T. Murby).—The Sanitary Condition of Oxfordshire: G. W. Child (Longmans).—Symond's Rainfall for 1873.—Sixteenth Report of the East Kent Natural History Society (Canterbury).—Amateur's Photographic Guide Book: Stillman (Smith, C.D.).—The Principles of Modern Pantheistic and Atheistic Philosophy: C. A. Row (Hardwicke).—Micrographic Dictionary. Parts xiii. and xiv.: Griffith and Henfrey (Van Voorst).

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